Groundbased observational campaigns of NEAs

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Introduction

Near Earth Asteroids (NEAs), are defined as minor planets having the perihelion distance $q \leq 1.3$ AU and the aphelion distance $Q \geq 0.983$ AU[1]. NEAs main formation mechanisms include migration of MBAs due to resonances, especially 3:1, 5:2, and 2:1 mean-motion with Jupiter and ν_6 with Saturn[2], possibly combined with the Yarkovsky/YORP effects[3]. Nowadays there are more than 9,200 known NEAs (MPC, 2012a). Potentially Hazardous Asteroids (PHAs) are currently defined based on parameters that measure the asteroid's potential to make threatening close approaches to the Earth. All asteroids with an Earth minimum orbit intersection distance (MOID) smaller than 0.05 AU and an absolute magnitude (*H*) of 22.0 or brighter are considered PHAs[4].

NEAs observation are important and circumscribe several scientific objectives such are: i) discovery of new objects; ii) confirmation of NEAs newly discovered; iii) secure large uncertainties orbits of NEAs; iv) shape determination from lightcurve analysis; v) scientific interest of specific objects potentially targets of "in-situ" investigations.

The article presents new astrometric observations performed at Pic du Midi Observatory in 2011 using 1-m telescope. In the same sense, the article presents the tentative of astrometry of WMAP satellite performed in the infrared region using 3m IRTF facility.

1. Observations and data reduction

The observations were performed during two runs, in March, 1-4, 2011 and November 17-24, 2011 at Pic du Midi Observatory. These two observational campaigns were conducted in the frame of EURONEAR program for confirming and secure NEAs orbits[5]. For the run of March 2011, the camera iKon-l Andor 2048x2048px in 2x2 binning mode was used. This is the main camera for astrometry and photometry used by 1-m telescope of Pic du Midi. It covers a field of view of 7.5x7.5arcminute. For the second run, the new Atick383L+ camera, in test as a spare camera, was used for both astrometry and photometry. This new camera has a 3326x2504 pixels which covers a field of view of 7.8x5.8 arcminute was used in 3x3 binning mode.

The observations were obtained using a broad-band B+V+R filter, covering the 0.39-0.680 μm spectral interval. The nights were relatively clear; the seeing estimation was 0.8-1.8arcsec for both runs. These conditions and the instruments allow a limit magnitude of V=20.5 for 180 sec of integration time (in the case of the first run) and V=20 for 180sec of integration time. During each night series of calibration images(flats, darks) were taken and used into the data-reduction process.

In order to increase the S/N ratio of the asteroid image the strategy of tracking of the observed fields at half the NEA proper motion was used. Thus, both asteroid and reference stars appear on the images with slightly elongated shape, enough to be detected by an automatic detection procedure.

In the frame of GAIA-FUN, as a training exercise for observations on alert, the asteroid (99942) Apophis was also observed during our campaigns. These observations represent a good test-sample for evaluating the possibilities and limitations of groundbased observations of future GAIA –asteroid discovery alert.

Into the global framework of GAIA missions, the observations were carried out on WMAP satellite, using the 3-m telescope Infra-Red Telescope Facility, located on Mauna Kea- Hawaii. The guiding camera of SpeX spectrograph 30x30 arcsec, 512x512pixels, was used for image acquisition. The images were obtained in the K band on June 27, 2009. While WMAP was never observed at such wavelength, a blind differential tracking calculated from its ephemeris for the image acquisition was used. The individual exposure time used during the run was 120sec. These observations were performed remotely from Paris Observatory, using CODAM facilities[6].

For data reduction, the Astrometrica software[7] was used and specific configuration file specific to the telescope/camera configuration. Astrometry was performed using USNO-B1 catalogue, NOMAD or UCAC2 one, depending on the field density of reference stars. The measured positions were reported as soon as possible to the Minor Planet Center.

Table 1. Summary of the results obtained on March 2011 is presented. Five of the objects were from NEO confirmation list. The columns are: object designation of the MPC database, provisory designation if the object need to be confirmed, number of distinct observations reported to the M.P.C., status of our report, and the M.P.E.C. confirming the newly discovered object.

OBJECT	Provisory	N. Obs	Status	Electronic Telegram
2000 EB14	SEB912A	12	Confirmed	MPEC 2011-E12 : 2000 EB14
2011 ET4	SE308D5	10	Confirmed	MPEC 2011-E14 : 2011 ET4
2011 ES4	SEB87C3	10	Confirmed	MPEC 2011-E13 : 2011 ES4
2007 ES	SEB9730	10	Confirmed	MPEC 2011-E11 : 2007 ES
2003 FC49	-	13	-	-
2011 CM17	-	11	-	-
2010 VN65	-	9	-	-
2010 RO82	-	8	-	-
2001 XB232	-	1	-	-
2011 EW4	-	1	-	-
2011 EX4	BY29967	9	Confirmed	MPEC 2011-E19 : 2011 EX4
2011 AF37	-	9	-	-

In the case of IRTF observations, the choice of the catalogue was oriented to the 2MASS one, because of density of the reference stars and their images obtained in the near-infrared filters (thus, a facility of identification of such a small field of 30x30 arcsec).

2. Results

2.1 *Pic du Midi Observations*

The targets were selected from NEO confirmation list[1] and from EURONEAR planning tool[2] which considers the list of objects desirable for astrometric observations (large uncertainties of the orbit). During 10 nights of observations in March and November 2011, 50 asteroids (34 NEAs) were observed and reported to MPC. Fifteen of them were subject of Minor Planet Electronic

[1]http://www.minorplanetcenter.net/iau/NEO/ToConfirm.html
[2]http://euronear.imcce.fr/tiki-index.php?page=Planning

Circulars(M.P.E.C.). The rest of observations appear in M.P.C daily orbit update. A sample of our report is presented in Table 1.

A brief statistics of the reported observations of these two runs is presented in Figures 1 & 2. The (o-c) values in right ascension are very well centered to zero value and the FWFM less than 0.7 arcsec shows a good quality of our astrometry. The small shift of the Gaussian fit of observation of about 0.1 arcseconds could be explained to be caused by a data-set astrometry of one (or more) asteroids for which the orbital parameters are not yet well constrained.

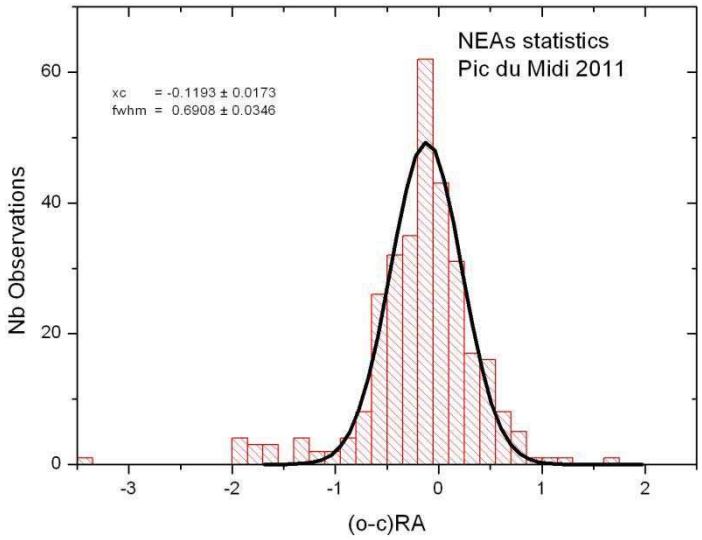

Fig. 1: Observed-Calculated (o-c) values in right ascension for 34 NEAs astrometric positions obtained in 2011 at Pic du Midi Observatory.

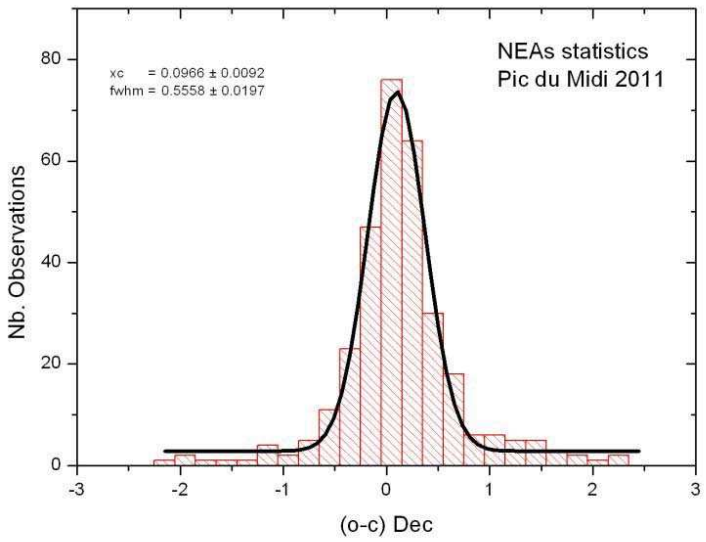

Fig. 2: Observed-Calculated (o-c) values in declination for 34 NEAs astrometric positions obtained in 2011 at Pic du Midi Observatory.

2.2 *IRTF Observations*

The images were centered on RA= +18H28M09.14S; DEC= -14°41'49.1". This field has a good density of star catalogue on the 2MASS one. The small FOV made the identification relatively heavy. Efforts of identification of WMAP in the center of the image (assuming the high quality ephemeris of the satellite) remain unsuccessfully either on individual images or in stacked ones.

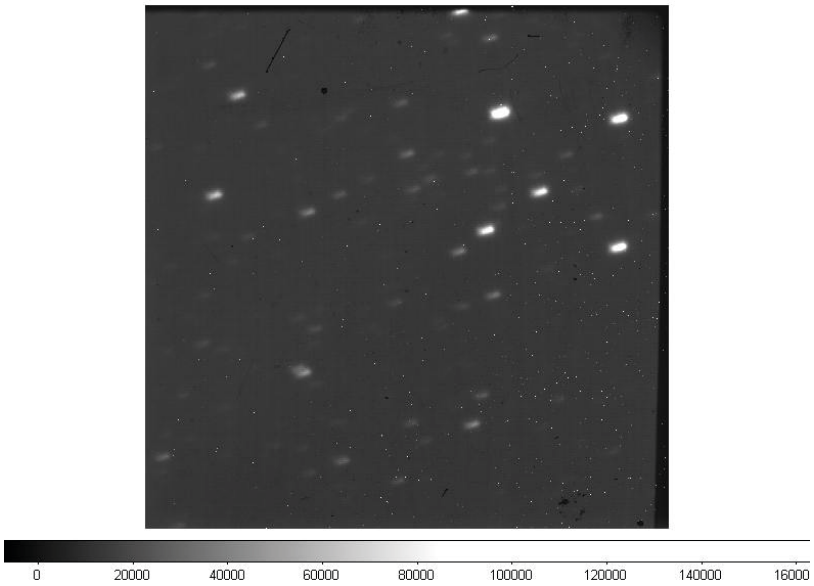

Fig. 3: Image of a 30x30 arcsec FOV obtained with SpeX/IRTF guiding camera. The image was obtained using 120sec integration time, and the stars PSF is slightly elongated because of differential tracking using WMAP ephemeris. WMAP is not visible but it should be in the center of the field. This low magnitude in the K band is explained by the high efficiency of thermal shield of the satellite.

Conclusion

NEAs population is a good laboratory of study for the Solar System dynamics. During two runs in 2011 at Pic du Midi Observatory 34 NEAs were observed and astrometry was reported to MPC. These observations confirmed newly discovered objects and reduce the uncertainty in orbital elements o a good number of observed NEAs. Tests on observations on alert in the frame of GAIA-FUN were performed for the NEA (99942) Apophis, following the strategy of this network.

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